UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

SAN JOSE DIVISION

IN RE HIGH-TECH EMPLOYEE ANTITRUST LITIGATION THIS DOCUMENT RELATES TO: ALL ACTIONS.	Master Docket No. 11-CV-2509 LHK

SUPPLEMENTAL EXPERT REPORT OF PROFESSOR KEVIN M. MURPHY

June 21, 2013

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I. INTRODUCTION

1. I have been asked by Counsel for Defendants to respond to the Supplemental Expert Report of Edward E. Leamer, Ph.D. ("Leamer Supplemental Report")[1] and to consider whether Dr. Leamer's analysis answers the Court's question whether "Defendants' salary structures were *so* rigid that compensation for employees with entirely different titles would necessarily move together through time such that a detrimental impact to an employee with one job title would necessarily result in an impact to other employees in entirely different jobs (*i.e.*, that any impact would ripple across the entire salary structure)."[2] I have concluded that Dr. Leamer's report contains fundamental errors of economics and statistics, and provides no evidence that the Defendants had such rigid compensation structures that suppressing wages of some employees would necessarily suppress wages of all or nearly all members of the proposed class.

2. First, Dr. Leamer's analysis is based on averages of compensation by job titles and average compensation for all job titles in the proposed class. He does not analyze the compensation of individual employees, so he ignores differences in compensation and compensation changes among employees with the same job title. Thus, his analysis cannot demonstrate the first required link in his theory of how the challenged conduct had class-wide impact, *i.e.*, that a raise to employees who receive a cold call would increase compensation even to other employees with the same job title.

3. Second, correlations of average compensation by job title with overall average compensation for the proposed Technical Class cannot show that raises for some employees necessarily would result in raises for some or all.

4. Third, neither his correlation analysis nor his regression analysis can distinguish a "somewhat rigid" compensation structure from one that is not. In particular, Dr. Leamer falls victim to two well-known statistical fallacies in constructing his regression model. In combination, these two fallacies virtually guarantee that Dr. Leamer will obtain the type of

[1] *Supplemental Expert Report of Edward E. Leamer*, May 10, 2013 ("Leamer Supplemental Report").

[2] In Re: High-Tech Employee Antitrust Litigation, *Order Granting in Part, Denying in Part Motion for Class Certification* (April 5, 2013) ("Order") at 36.

regression results that he does, even if there is zero effect of an individual's pay on the pay of others.

5. Fourth, Dr. Leamer does not establish that the proposed class is properly defined.

6. Finally, Dr. Leamer did not address the Court's invitation to "improve the accuracy" of the Conduct Regression that he offers as evidence of "generalized" impact and damages, and thus did not respond to the lack of precision of his estimates.[3]

II. THE VARIATION IN INDIVIDUAL COMPENSATION, WHICH DR. LEAMER'S ANALYSES IGNORE, SHOWS THAT A RAISE FOR ONE OR SOME DOES NOT NECESSARILY CAUSE A RAISE FOR ALL OR NEARLY ALL

7. The question that I consider relevant for evaluating the Court's concerns about Plaintiffs' claims is whether a change in compensation at one point in the compensation structure would cause a change in compensation for the class as a whole. This is different than whether average compensation for different job titles moves together, since co-movement could simply reflect the response to common factors that have nothing to do with Dr. Leamer's "sharing" theory. Co-movement, which is the focus of Dr. Leamer's empirical analysis, is not informative as to how compensation of different class members would differ absent the alleged cold-calling agreements. To illustrate the difference between correlation (or co-movement) and causation, the use of umbrellas and windshield wipers in a city are highly correlated, but neither causes the other. Rather, they are both caused by a common external factor: rain.

A. Dr. Leamer Focuses on Correlations of Average Compensation for Job Titles with Overall Average Compensation and He Does Not Analyze the Substantial Variation in Compensation Changes for Individual Employees

8. Dr. Leamer's empirical analysis focuses on whether changes in average compensation for various job titles are correlated with movements in the average compensation level for the proposed class as a whole. He does not examine whether changes in compensation at the individual level, which is where the initial impact of any cold call would occur, necessarily cause

[3] Order at 42-43 and fn. 15.

changes in compensation for all or nearly all employees in the same job title or for the proposed class as a whole.

9. Dr. Leamer offers no empirical evidence that demonstrates the type of propagation that Plaintiffs postulate—either across individuals within the same job title or across job titles. He acknowledged that the compensation data available to him could be studied at the individual level. But he chose to work with "title averages," claiming that "the individual data is likely to be dominated by forces that operate at the individual level" and that "[a]veraging across individuals in a title can average out the individual effects."[4] However, it is precisely those forces and individual effects that determine whether, as the Court asked, "Defendants' salary structures were *so* rigid that compensation for employees with entirely different titles would necessarily move together through time such that a detrimental impact to an employee with one job title would necessarily result in an impact to other employees in entirely different jobs (*i.e.*, that any impact would ripple across the entire salary structure)."[5]

10. The amount of variation in compensation of individual employees over time determines whether a firm has to adjust compensation of a large number of individuals if it chooses to increase the compensation of an individual who receives a cold call. If individual pay were always identical for individuals within a job title, or if compensation were determined by a fixed formula (e.g., based only on objective factors such as level of tenure in the job with no deviation permitted), then a change in compensation for one individual would require a change for other individuals in that same job (assuming that the firm does not respond when an individual receives a cold call by promoting her to a better paid job title). In contrast, if, as a regular matter, there is wide variation in compensation changes for individuals in the same job, one cannot presume (as Dr. Leamer appears to do) that an increase in compensation for one employee in response to a cold-call would cause an increase in compensation for all employees with the same job title, because the firm has sufficient flexibility to respond to outside pressure on compensation of a given individual (such as pressure resulting from a cold call) to adjust compensation for that employee without changing compensation for other employees, even those

[4] Leamer Supplemental Report ¶19.

[5] Order at 36.

in the same job title. For example, the firm can provide one-time retention bonuses or stock grants, increase base salary within the existing salary range for that title, or promote the individual to another job title with a higher salary. Moreover, the firm would have an incentive to respond in one of these other ways rather than adjust compensation broadly, since doing so would allow the firm to minimize its labor costs.

11. Data on compensation of individuals, which I discuss below, show that, consistent with that flexibility, there is substantial divergence in compensation of individuals within a job title. In particular, the Defendants routinely differentiate increases (and decreases) in pay across employees. Even within individual job titles, annual compensation changes at the individual level show a mixture of large and small increases and decreases at a given point in time. While compensation received by individual employees at a firm tends to be positively correlated over time, there is substantial individualization of pay.

12. The existence of positive correlations does not support Dr. Leamer's "sharing" theory, because it reflects the fact that there are many common factors that can cause similar adjustments in employee compensation firm wide. Dr. Leamer himself identifies such a factor when he argues that "the Pixar data are *contaminated* by very large bonuses for producers and directors in 2002 and 2006,"[6] although he fails to acknowledge that this type of "contamination" is exactly what his correlation analysis reflects. Similarly, Intel's decision to freeze salaries in 2009[7] is a common factor that would have affected compensation levels and changes in that year. Apple's tremendous success in recent years and Google's transformation from a relative newcomer to a well-established tech firm fall into a similar category. However, while compensation received by individual employees is affected by common factors, it also is affected by other factors that result in substantial "uncommon" changes over time.

[6] Leamer Supplemental Report ¶67.

[7] Agam Shah, "Intel Freezes Salaries from CEO on Down," Computerworld, March 23, 2009.

B. There Is Sufficient Variation in Compensation Across Individuals With The Same Job Title That One Cannot Assume That Adjusting One Employee's Compensation Requires Adjusting Others

13. I performed several analyses to understand the extent to which compensation of individual employees moves together. Exhibit 1 displays the cumulative compensation histories for all employees within a single selected job title at each of the Defendants.[8] These exhibits are meant simply to illustrate the type of variation in compensation of individual employees that is present throughout the data (and that I summarize more systematically in my subsequent exhibits).

14. Exhibit 1 shows that individuals who start with the same job title have very different cumulative changes in compensation over time, and can end up with very different compensation in 2010 compared to 2005. This substantial divergence in compensation over time is fully consistent with correlation levels that are "high."[9] In other words, correlated time series can diverge substantially, and can have substantial year-to-year changes in levels.

15. Exhibit 2 examines compensation changes between 2007 and 2008 (years in the middle of the class period) in the top three job titles at each Defendant (based on number of employees in 2007). The exhibit summarizes the large annual variation in changes in compensation for individuals who start in the same job.[10] For example, compensation changes for Adobe's employees with the title of [redacted] vary in sign and magnitude, with some individuals receiving large increases (more than 25 percent) and others

[8] I selected the job titles by restricting the data to class members who remained employed by the Defendant in that job title in each year from 2005 through 2010 (2006-2010 for Lucasfilm because its data did not include job titles before 2006). I then selected for each Defendant the job title that included 25 employees (or the closest number to 25) in order to have examples with as many employees as seemed reasonable to display graphically in a single chart. If more than one job title contained 25 employees, then I selected the first one ranked alphabetically.

[9] According to Dr. Leamer, "A high positive correlation means that compensation of a title moves in a way that is similar to compensation in the rest of the Technical Class, thus supporting the conclusion that the title and the class have "coordinated" compensation levels, a fact which is consistent with sharing of gains and broad impact of the anti-cold-calling conspiracy whether it directly affects the title under study or the rest of the Technical Class" (Leamer Supplemental Report ¶51). I infer from this that Dr. Leamer considers his calculated correlations to be "high" and "positive."

[10] I include individuals that change job titles in my analysis because moving an individual into a new job title (e.g., promoting him from a Software Engineer 3 to a Software Engineer 4) is one way in which a firm can increase an individual's compensation (in response to a cold call or otherwise) without adjusting the firm's compensation structure more broadly.

suffering large decreases (more than 25 percent). Taken together, Exhibit 2 and the summary statistics based on this type of analysis for more years and a larger number of jobs at each of the seven Defendant firms in Appendix B show that there is substantial room for a firm to adjust compensation differently for different individual employees, including those with the same job title, and that Defendants take advantage of this flexibility.

16. Exhibit 3 examines average annual changes in individuals' compensation between 2001 and 2011 after adjusting for individual characteristics (in effect, standardizing the changes across individuals by eliminating systematic impacts on compensation that reflect age, tenure, gender and job title).[11] The differentiation summarized in this exhibit reflects the differences between the change in compensation for an individual and what would be predicted based on changes in the overall compensation structure and that individual's characteristics and job. A value of +10 percent indicates that the individual obtained an increase 10 percent greater than equivalent "peers," while -10 percent indicates that the individual received 10 percent less than equivalent peers. Again, the results show that Defendants exercise substantial flexibility in adjusting individual compensation, with a wide distribution of annual adjusted changes (shown in the exhibit as deviations from the average change for the year).

17. Exhibit 4 summarizes the data from Exhibit 3. I group the data into four categories by compensation change, and show in the exhibit the top and bottom 10 percent (deciles) and the top and bottom 25 percent (quartiles). The exhibit shows the large differences in compensation changes between employees with the lowest compensation changes and those with the highest compensation changes (after controlling for age, tenure, gender, and job title). For example, at Adobe, employees in the bottom decile of the distribution have annual compensation changes that are 29 percent below the average; employees in the top decile of the distribution have annual compensation changes that are 29 percent above the average. Thus, the difference in the compensation changes between these two groups is nearly 60 percent—the top group's annual compensation increase is, on average, 60 percent higher than the increase of the bottom group. Similarly, the difference in the compensation changes between the employees in the bottom

[11] This comparison eliminates systematic effects, such as larger average increases for younger employees or for those with less tenure.

quartile at Adobe and those in the top quartile is almost 40 percent.[12] The large variation in compensation changes at Adobe, as well as at the other six Defendants, shows that there is ample room for a firm to adjust the compensation of one employee without adjusting the compensation of others.

18. Thus, Exhibits 1-4 show that the Defendant firms routinely adjust compensation at the individual level. As a result, there is sufficient variation in rates of compensation growth for individual employees, even within the same job title, that a firm can increase compensation of an employee who receives an outside offer without adjusting compensation of other employees with the same job title.[13]

III. PROPERLY INTERPRETED, DR. LEAMER'S "CORRELATION" EVIDENCE SHOWS THAT LITTLE VARIATION IN AVERAGE JOB-LEVEL COMPENSATION IS "EXPLAINED" BY CHANGES IN CLASS-WIDE AVERAGE COMPENSATION

19. Dr. Leamer presents "correlations that compare the movement over time of the average compensation of each title with the average compensation of the firm's Technical Class," and claims that these calculations reveal a "large amount of co-movement of compensation among most of the Technical Class titles of each defendant."[14] He claims that this co-movement is "consistent with a top-down budgeting method" and a "'somewhat rigid' salary structure, which allows the effects of the anti-cold-calling conspiracy to spread broadly across each firm."[15]

20. However, whether the correlation evidence is "consistent with" his theory is only part of the issue that Dr. Leamer must address in order to support his theory. More relevant for purposes of understanding whether Plaintiffs' claims have merit is whether evidence of co-movement is *inconsistent* with a compensation structure that is not rigid in the way that Dr. Leamer claims. The essence of hypothesis testing is not to provide evidence "consistent with" a

[12] The difference between a 19 percent increase and a 19 percent decrease is 38 percent. In Exhibits 3-6, percent differences are defined as differences in logs.

[13] Appendix A provides additional evidence, relied upon by Dr. Leamer in his Reply Report, of the dispersion of compensation changes for employees at Intel and Apple within a single job title.

[14] Leamer Supplemental Report ¶4.

[15] Leamer Supplemental Report ¶4.

hypothesis, but to offer evidence capable of rejecting that hypothesis if it were not true. Evidence that is equally consistent with the theory being true and the theory being false is not informative. Dr. Leamer's analysis fails to meet this essential principle of scientific methodology.

21. In the language of economics, Dr. Leamer implies that his correlations reflect causality[16] – that a change in one variable leads to or causes a change in the other – but he then offers only evidence of co-movement. However, correlation, or similar movement, in average job-title compensation does not establish the necessary causation to support Dr. Leamer's theory. Moreover, as I explain below, Dr. Leamer also overstates the similarity in movement and mischaracterizes the implications of the measured correlations.

A. It is Deviations in Compensation, Not Correlations, that Matter for Evaluating Plaintiffs' Claims

22. Dr. Leamer does not explain what his correlation coefficients imply about his claim of a somewhat rigid compensation. Correlation measures the degree to which two series are linearly related to one another,[17] but not how much the two series deviate over time. There can be large deviations between the series, even though they have a "high" correlation coefficient. Economics tells us that what is relevant in understanding the rigidity of a firm's compensation structure is the extent to which compensation of alternative job titles deviate from one another, not whether they are weakly or strongly correlated. If they track closely, then the firm has exercised little scope to differentiate pay across job titles. If they diverge substantially, then the firm can and does differentiate pay across job titles. Even if, as Dr. Leamer claims, a "Large Share of [Job Title] Change Correlations are Positive," it does not follow that Defendants have compensation structures that require them to change compensation for all, or nearly all, class members if they raise one employee's compensation in response to a cold call.

23. Exhibit 5 shows the variation in annual changes in job-level average compensation after adjusting for individual characteristics (age, tenure, gender and job title) over the period 2001-

[16] Leamer Supplemental Report ¶42, 46.

[17] *See*, for example, George Casella and Roger L. Berger, *Statistical Inference*, 1990, pp. 160-168.

2011.[18] The exhibit shows that there is substantial variation in annual changes for all firms. This distribution of changes in job-level average compensation is summarized in Exhibit 6.[19] As I did in Exhibit 4 (which summarizes the employee-level changes), I group data into categories by compensation change to show the large differences between the jobs (weighted by the number of employee-years) with the largest compensation changes and those with the smallest compensation changes. Using Adobe as an example, the jobs in the top decile increased by 16 percent relative to the average, while the jobs with the largest negative deviations decreased by 15 percent relative to the average. Thus, the annual change in job average compensation at Adobe was about 30 percent higher in jobs in the top decile than in jobs in the bottom decile (after adjusting for differences in the characteristics of the employees in each job). Similarly, the changes in job average compensation at Adobe was almost 20 percent higher in jobs in the top quartile than in jobs in the bottom quartile. The variation in changes in job average compensation is largest for Google and Pixar and smallest for Intel, but is economically large for all Defendants.

24. Exhibits 7 and 8 extend the analysis of the top 25 job titles from my initial report (see Exhibit 18 in that report), where I showed that there was wide variation in annual compensation changes for these job titles. In Exhibit 7, I select a sample of the most common jobs that span across each of Dr. Leamer's deciles for each Defendant, and plot the annual changes in average compensation at each job.[20] The exhibits confirm that, rather than moving in lockstep, average

[18] Data for Lucasfilm are limited to 2006-2011.

[19] These calculations correct for the difference in individual characteristics across titles by using annual-level regressions of compensation changes on individual characteristics and fixed job effects. The job-level deviations are measured by the fixed job effects in these regressions. Correcting for individual characteristics makes very little difference to the results, but Dr. Leamer has expressed concern that variation in individual characteristics may be generating some of the variation over time in job-level compensation (Expert Report of Edward E. Leamer, Ph.D., October 1, 2012, ¶¶128-134). I also have calculated the same statistics without correcting for individual characteristics and obtain very similar results which support the same economic conclusions.

[20] I select the jobs as follows. First, I take the top five jobs from each of the ten deciles at each Defendant. Because some deciles have fewer than five jobs, I have fewer than 50 jobs for most Defendants after this first step. Second, I take the next largest jobs (based on 2001-2011 employment, which is the same employment measure used by Dr. Leamer when constructing his deciles) until I have 50 jobs for each Defendant. Finally, when plotting the changes, I require the average number of employees across the two years for which I am calculating the change to be at least five. The number of jobs plotted ranges from 9 (at Google in 2002) to 50 (at Intel in years 2004 through 2011).

job-level compensation changes in any given year vary both in sign and magnitude, with some jobs seeing large increases, some large decreases and others smaller increases or decreases.[21]

25. Exhibit 8 extends the time period and looks at 2-, 3-, 4- and 5-year changes in average job-title compensation relative to 2005, rather than the sequence of annual changes.[22] Over longer time frames, compensation for the majority of jobs increased, which simply means that wage growth is greater over the long term than the short term. But a "somewhat rigid" wage structure requires more than that. Rigidity has to do with whether the increase in compensation for all jobs is roughly the same or, at a minimum, changes in a systematic way. If, for example, average compensation routinely increases by 50 percent for one job and only 10 percent for another job, one cannot conclude that an increase in pay for one group caused by an employee receiving a cold-call or for some other reason was "shared" with the other group. Indeed, the fact that pay went up 40 percent more for one group than the other implies that increases in pay across jobs were not common, and that the wage "structure" changes substantially over time rather than remains rigid.

B. Correlation Levels that Dr. Leamer Finds "Astounding"[23] Imply that Almost All the Variation in Job-Level Compensation is *Not Explained* by Class-Wide Average Compensation

26. Dr. Leamer reached the wrong conclusion about the rigidity of the Defendants' compensation structures from his correlation analysis because it appears that he did not consider what a particular level of correlation implies for the supposed rigidity of the compensation structure. He provides no means of evaluating whether a correlation of, say, 0.4 is sufficient to conclude that a compensation structure is somewhat rigid.

[21] Exhibits 7 and 8 show changes in the raw data. I have also looked at versions of these charts adjusting the compensation changes for individual characteristics and fixed job effects. Adjusting for individual characteristics makes very little difference to the results.

[22] I have performed the same analysis for starting years of 2004 and 2006 because the starting year matters somewhat for the average level of change (although much less so for the variation in changes), and the results are comparable.

[23] Leamer Dep. at 563:8-15.

27. Dr. Leamer calculates correlation between changes in job-level averages and the class-wide average compensation[24] that range from -0.96 to 0.99 across the seven Defendants. This average hides wide variation in the estimated correlations across jobs. But, his conclusion would be unwarranted even if all of the true correlations between job-level compensation changes and class-wide average compensation were equal to his average estimated correlation (roughly 0.60).[25]

28. It is important to understand what a correlation means in order to interpret and evaluate Dr. Leamer's findings. A correlation of 0.6 between the average compensation for a job title and the class-wide average means that 64 percent of the variance remains after controlling for changes in the class-wide average ($= 1 - .6^2$). The amount of variation that remains after accounting for movements in the class-wide average equals the square root of 0.64, or 0.80. This means that the remaining variation in job-level compensation after controlling for changes in average class-level compensation is 80 percent of the total variation in job-level compensation in the raw data, or *only 20 percent less than if there were no correlation at all*.[26]

29. Given that Defendants' data show that job-level compensation does not move in lockstep, or anything close to it, there is no economically meaningful sense in which Defendants have somewhat rigid compensation structures that would necessitate sharing of compensation jobs across the class irrespective of the correlation coefficients that Dr. Leamer calculates. The wide variation across individual employees within a job title does not support Dr. Leamer's inference that, in the Court's words, "the Defendants' salary structures were *so* rigid that compensation for employees with entirely different titles would necessarily move together through time such that a detrimental impact to an employee with one job title would necessarily result in an impact to

[24] Dr. Leamer actually uses the average of class-wide compensation excluding the job at issue. Given the number of jobs, this is similar to the class-wide average compensation.

[25] In his backup, Dr. Leamer provided an estimate of the mean correlation by firm based on his "shrinkage" methodology. The average across Defendants of these measures is 0.57. I use 0.6 for illustrative purposes.

[26] The square of the correlation coefficient, which measures the percentage of the variance in job-level compensation changes that are explained by changes in the class-wide average, is .36 ($0.36 = 0.6^2$ in this example). However, the range of variation in compensation changes we observe is measured by the standard deviation (which equals the square root of the variance), not the variance. This shows why Dr. Leamer's focus on the degree of correlation is so misguided.

other employees in entirely different jobs (*i.e.*, that any impact would ripple across the entire salary structure)."[27]

IV. DR. LEAMER'S REGRESSION ANALYSIS DOES NOT SHOW THAT FORCES OF INTERNAL EQUITY COMBINED WITH THE HYPOTHESIZED "SOMEWHAT RIGID" WAGE STRUCTURE GENERATE CLASS-WIDE IMPACT FROM THE CHALLENGED AGREEMENTS

30. Dr. Leamer explains the rationale for and conclusions to be drawn from his regression model as follows:

> Correlation of title compensation and class compensation could come from sharing effects but could also come from third variables that operate on both title and class compensation at the same time, for example, "market forces." To *confirm* the existence of a somewhat rigid compensation structure revealed by my correlation analysis, I examine (company by company) a multiple regression model which *forces the class compensation to compete with other variables as an explanation of title compensation*.[28]

Based on this analysis, Dr. Leamer claims to demonstrate that increased compensation for individuals in one part of the firm (e.g., within a particular job title) would "ripple" to (or, as he refers to it, "be shared" with) all other employees in the proposed Technical Class. He claims to do so with a regression model that demonstrates two types of "sharing." First, Dr. Leamer claims to find contemporaneous sharing in which an increase in compensation for one group (a job title) causes a contemporaneous increase in compensation for other groups (other job titles in the class). Second, he claims to find lagged sharing that demonstrates a form of "catch-up" in which compensation for a group that falls behind in one year increases the following year through some unspecified "corrective action" to become closer to its "normal" level relative to the rest of the class.

31. However, both of Dr. Leamer's inferences regarding sharing are unsupported by his regression and are entirely unfounded. His regression model suffers from two well-known statistical fallacies – the "reflection problem" and "reversion to the mean" – that make his interpretation of the sign and statistical significance of coefficients on the sharing and external variables in his regression for purposes of evaluating his theory improper. In combination, these

[27] Order at 36.

[28] Leamer Supplemental Report ¶24 (footnote omitted, emphasis added).

two statistical fallacies virtually guarantee that Dr. Leamer will obtain the results that he does, even if his theory is wrong and there is no effect of one individual's compensation on the compensation of other employees and no impact of changes in average compensation for one job on average compensation for other jobs (i.e. no "sharing").

A. Dr. Leamer Ignores the "Reflection Problem"

32. Dr. Leamer commits a long-recognized error of statistical inference. He ignores the "reflection problem" in concluding that the change in average class compensation causes the average compensation of a job title to increase. As a consequence, Dr. Leamer would expect to obtain the same regression results even if there were no "sharing," and no propagation of a cold-call related increase in compensation for one employee or a small group of employees into increases in compensation for the rest of the proposed class.

33. The canonical example to illustrate the reflection problem is the relationship between one individual's test scores and the average test scores of the individual's classmates. There will tend to be a positive relationship between the performance of the individual and her classmates. If one uses a regression like Dr. Leamer's, the positive coefficient on the classmates' average test scores will show that a higher average score for an individual's classmates are associated with higher score for the individual. However, this result provides no information to distinguish between two alternative theories: (1) that the student does better because she is in a class with higher performing classmates (in Dr. Leamer's terminology, that the achievements of classmates are "shared" or transmitted to an individual student) or (2) that both the student and her classmates are influenced by common factors, such as the quality of the school or teacher or a more advantageous family background. A regression like that estimated by Dr. Leamer does not permit one to tell which is correct, because both theories could explain why a student performs better when she is in classroom with better students.[29]

34. This is the reflection problem, and it is the fallacy that Dr. Leamer commits. The coefficient on his contemporaneous variable merely shows that there is correlation between changes in compensation of one job title and the average compensation of the class, but it does not reveal the cause of that correlation. Indeed, finding that compensation for a given job

[29] This problem is a critical issue in deriving conclusions from analyses such as those performed by Dr. Leamer.

increases more than normal when the average increase for all other jobs in the class is larger than normal is hardly surprising, even in the absence of sharing. After all, the class-wide average outcome is essentially the average of the outcomes for the constituent groups.

35. The "reflection problem" is a well-known pitfall in interpreting regressions like those offered by Dr. Leamer that attempt to identify whether group-level outcomes (in this case, compensation for the class as a whole) influences individual-level outcomes (in this case, average job-level compensation). As described by Professor Charles F. Manski, who pioneered the research in this area, correlation between group behavior and individual behavior cannot by itself answer the question whether group behavior influenced individual behavior:

> This identification problem arises because mean [average] behavior in the group is itself determined by the behavior of group members. Hence, data on outcomes do not reveal whether group behavior actually affects individual behavior, or group behavior is simply the aggregation of individual behaviors. This *reflection problem* is similar to the problem of interpreting the (almost) simultaneous movements of a person and his reflection in a mirror. Does the mirror image cause the person's movements or reflect them?[30]

Generally, when individuals in a group are subject to at least some common influences, it will appear that they are responding to each other even when they are not. Moreover, this can be true even when such common factors are relatively unimportant determinants of individual outcomes.

36. In the Technical Appendix, I explain how the statistical property known as the reflection problem makes Dr. Leamer's conclusions about "sharing" and "catch-up" unjustified. The import of that analysis is as follows. Consider a hypothetical firm with many job titles. Compensation in each job title is determined solely by the sum of two types of factors: (1) common factors (firm-level success, changes in the general economy, etc.) and (2) job-specific factors (group-level performance, changes in the market for individual skills, etc.). One can illustrate the fallacy in Dr. Leamer's results by considering the case where these job-specific factors are completely independent across jobs. In other words, there is no "sharing" – no impact of compensation in one job on compensation in any other job – because the job-specific factors are entirely independent of and do not influence one another.

[30] Charles F. Manski, "Economic Analysis of Social Interactions" 14 J. Econ. Perspectives 115 (2000), at 128. Understanding mean reversion (or simultaneity) in data is an important issue when evaluating policy interventions (see Robert A. Moffitt, "Policy Interventions, Low-Level Equilibria, and Social Interactions" in *Social Dynamics*. MIT Press, 2001, Section 3.2.1 – Simultaneity).

37. Now consider Dr. Leamer's regression, which he says demonstrates that there is "sharing" of compensation adjustments between job titles. In essence, what Dr. Leamer does is to substitute a variable that measures the change in average compensation for the rest of the class (his "contemporaneous sharing" variable) for the common and job-specific variables that are the true determinants of job-specific compensation. Thus, his sharing variable reflects changes in compensation for all the other jobs at the firm, even though, by assumption, compensation changes for those other jobs have no direct causal impact on the change in compensation of a particular job (because job-specific factors are totally independent). The consequence is that his estimated coefficient on this variable will reflect the variance of changes in the common factors and the variance of the changes in job title-specific factors for all the job titles, but (for the technical reason that I explain in the Technical Appendix) the magnitude of the estimate will be dominated by the common factors (rather than job-specific factors) when the firm has many different job titles contributing to firm-wide average compensation. As a result, the measure of the change in average compensation for the firm effectively serves as a proxy for the common factors that affect both compensation of the particular job title and compensation of all other jobs at the firm. The coefficient on the change in class-wide compensation does not measure "sharing" or any causal relationship between compensation of a particular job and the job-specific factors that influence compensation for other jobs. Nevertheless, Dr. Leamer interprets his results as proof that the change in job title compensation is caused by sharing because he fails to recognize the reflection problem.

38. Dr. Leamer's confusion about what he can conclude from this correlation evidence, and the relevance of external factors, was apparent at this deposition. He testified that changes in compensation for the various job titles at Adobe between 2001 and 2003, during the "tech bust," were particularly useful for testing his rigid compensation structure and sharing theories.[31] But this is exactly the wrong type of variation (a shock common to Adobe as a whole and indeed to the entire tech industry) to test his theory that cold calls to individual employees would be "shared" with all or nearly all Technical Class employees. The fact that compensation for many or even all groups of employees at Adobe fell when there was a common shock (the tech-bust) that affected Adobe's business as a whole and the local labor market broadly, and then rose when

[31] Deposition of Edward Leamer, June 11, 2013 ("Leamer Dep.") at 747:17-749:16.

economic conditions improved, does not show that a force that operates directly on one group of employees would ripple out to (*cause* compensation changes for) others. Shocks that directly affect many groups would be reflected in correlation of compensation of those groups, even if there were no linkages at all.

39. Furthermore, Dr. Leamer's characterization of his average compensation change and lagged compensation change variables as "internal factors" that cause changes in average compensation for a job makes no sense. Changes in average compensation of the class cannot be the ultimate "cause" of changes in job-level compensation, because the change in the overall average is determined by the changes in average compensation of the jobs that comprise that class average. In a sense, this conceptual error is at the heart of the "reflection problem" – as a matter of economic logic, both the overall average and its components must be determined by some underlying factors that Dr. Leamer has not identified. His analysis cannot reveal whether these underlying factors are internal (which one might define to be firm-specific factors) or instead are driven by the external marketplace.

40. The simple, but important, implication of Dr. Leamer's confounding of internal and external factors is that there must be omitted factors in Dr. Leamer's model, or there can be no adjustment process of the type that he claims. If we accept his estimated "sharing" model, then there must be some cause that initiates the deviations from his somewhat rigid compensation structure, and thus leads to the changes in overall average compensation which then are propagated throughout the compensation structure. Once one admits that such unmeasured factors exist, but that they are unidentified, it is pure faith to claim, as Dr. Leamer does, that they are not common.

B. Dr. Leamer's "Horse Race" Is Uninformative

41. Dr. Leamer does not completely ignore the fact that common factors can generate the appearance of sharing even when none actually exists. To test whether his "sharing effect" simply reflects "external factors" that are common across job titles,[32] he claims to have run a "horse race" between the "sharing" effects that underlie his theory and external factors that, if they were the cause of his results, would refute his theory. Based on this analysis, which he

[32] Leamer Dep. at 571:25-573:3 and 597:21-598:2.

implements by including "external" factors in the same regression as the two "sharing" variables, he concludes that "[t]he regression analysis reported above indicates that the internal sharing effects are generally more detectable than either revenue sharing or the external market forces."[33]

42. Dr. Leamer's "horse race" is flawed, just like his methodology in general. His results simply reinforce his errors of interpretation rather than providing information about the underlying data. In the Technical Appendix, I illustrate this by showing what happens when some measured common factors are added to the model. I show that, when measured common factors (in his case San Jose employment and firm revenue) that capture only a portion of the variance in common factors (with the rest being unmeasured) are included, the coefficient on the measured external factors will reflect only a small fraction of the true impact of the external factors, while the estimated coefficient on the firm-wide average compensation change will decline only slightly (the technical explanation for this is in the Appendix). For example, in the model that I develop in the Technical Appendix, adding factors that account for 50 percent (a relatively large fraction) of the common factors reduces the estimated sharing effect from 0.86 to 0.75. In addition, the estimated impact of the common factors that are included in the regression is only one-quarter of its true size.

43. This downward bias in the estimated effect of Dr. Leamer's "external factors" is once again a well-known problem in econometrics. The classic example can be seen in the economics of education. If an analyst constructed a regression model in which income was a function of education and an individual's lagged income, the coefficient on education in the regression will understate, perhaps dramatically, how much education contributes to the individual's income. The problem is that education also increases lagged income and therefore part (maybe most) of the effect of education on income will be captured by this lagged effect rather than by the education variable itself. At a technical level, Dr. Leamer's regression model suffers from what is known in econometrics as an "endogeneity problem," which arises when some of the same unmeasured common factors drive both the independent and dependent variables. It is well known that including an endogenous variable (i.e., one that is correlated with the omitted factors – here, lagged income) will bias coefficients on both the endogenous variable (in this case the

[33] Leamer Supplemental Report ¶65.

sharing variable) and on the other variables included in the regression (in this case, education),[34] and that controlling for some of these omitted factors does not solve this problem.

44. The consequence is that Dr. Leamer's analysis and the "horse race" that he claims supports the "somewhat rigid" compensation structure on which his theory relies are uninformative. His "horse race" between his "sharing" and "external" variables was fixed, because the statistical properties of the model predetermine that the "external" variables he added would not matter substantially and that his "result" that internal sharing was important would survive even when it does not represent the underlying process that generates the data (i.e. even when there is no sharing).

C. Dr. Leamer Does Not Take Into Account the Tendency of Compensation to "Revert to the Mean"

45. Dr. Leamer's second statistical fallacy arises from "reversion to the mean" and is known as the "regression fallacy."[35] The regression fallacy arises when an analyst examines a data series that is subject to shocks that are, at least to some extent, temporary, and ignores the tendency of such data to "regress" or revert to the mean of the distribution. Reversion to the mean describes many phenomena, such as the tendency for athletes who perform extremely well or extremely poorly in one year to perform more like the average athlete in the following year. With employee compensation data, it reflects the tendency of an individual who receives an exceptionally large bonus or other form of compensation in one year to receive a smaller bonus or other compensation in the following year (although one that still may be above average).

46. A simple illustration of this phenomenon is the expected compensation of a salesman who is paid on commission. In any year, the salesman's compensation can be low (assume $75,000), medium ($100,000), or high ($125,000) based on whether it was a bad, average or good year. Assume that one third of the years are good, another third are average, and the rest are bad. If year one is good, and the salesman earns $125,000, then there are three equally likely

[34] Endogeneity causes the ordinary least squares estimator to be biased and inconsistent. *See* for example, William H. Greene, *Econometric Analysis*, Sixth Edition, Chapter 12. See also Robert S. Pindyck and Daniel L. Rubinfeld, *Econometric Models and Economic Forecasts*, Fourth Edition, Chapter 12.

[35] *See*, e.g., Milton Friedman, "Do Old Fallacies Ever Die?" 30 J. Econ. Literature 2129 (1992). Friedman says that he "suspect[s] that the regression fallacy is the most common fallacy in the statistical analysis of economic data." He also notes that "the phenomenon in question is what gave regression analysis its name."

possible changes for next year: next year is good (compensation of $125,000 and no change from year one); next year is average (compensation of $100,000 and a decline of $25,000 in compensation year over year); and next year is bad (compensation of $75,000 and a decline of $50,000 in compensation year over year). Since, by assumption, the three outcomes are equally likely, the expected change in compensation is -$25,000 (($0-$25,000-$50,000)/3). In contrast, if year one were a bad year (compensation of $75,000), the potential changes in compensation the follow year are +$50,000, +$25,000 and zero, and the expected change is therefore +$25,000. If year one is an average year, the three possibilities are no change, +$25,000 and -$25,000, for an expected change of zero. The first two scenarios demonstrate expected reversion to the mean compensation level of $100,000.

47. Exhibit 9 plots the data generated by this process. The level of compensation in year one is measured on the horizontal axis and the change in compensation from year one to year two is measured on the vertical axis. The exhibit shows the regression line that would result from regressing the change in compensation from year one to year two on the level of compensation in year one. The line has slope -1.0, which reflects the fact that the extra compensation (relative to the average) earned today – which is +$25,000 in a good year and -$25,000 in a bad year – is not expected to persist in year two, but instead will "revert" in year two to the average of $0.[36] An analyst that applied Dr. Leamer's methodology could mistakenly conclude from a regression analysis of the change in compensation from year one to year two on the level of compensation in year one that the firm is constantly adjusting the salesman's compensation to keep it in line with the long-run average (that the firm is actively "catching-up" the salesman's compensation to the normal level in Dr. Leamer's terminology), when in fact the firm plays no active role at all. Rather, it is the natural variation in pay that generates what appear to be systematic adjustments to compensation.

[36] This example is easily extended to allow for persistence in compensation over time. In particular, if we assume that the state persists with probability $p<1$ (i.e. if times are good this year, they will be good the next year with probability p and shift to being average or bad each with probability (1-p)/2 then the regression coefficient will be -3/2(1-p)). When $p=1/3$ then we have the same case discussed above (no persistence). As long as $p<1$, i.e. there is some temporary component to compensation, the regression coefficient will be negative.

48. At his deposition, Dr. Leamer claimed that reversion to the mean was not a problem that affected interpretation of his analysis or its relevance in supporting Plaintiffs' claims.[37] He appeared to acknowledge that firms could respond to the pressures for internal equity with bonuses and stock grants, which are less visible and so might not be as likely to generate internal equity concerns.[38] However, even if this were true, it does not vindicate Dr. Leamer's methodology or make his conclusions sensible, but instead explains why his theory makes no sense. A firm that uses less visible forms of compensation (bonuses and stock grants) to increase compensation for some individuals without succumbing to pressures for internal equity and adjusting all employees' compensation can avoid "sharing." The compensation data would then make it appear that there was a large "lagged sharing" or "catch-up" effect in Dr. Leamer's regression because of the strong reversion to the mean generated when compensation is adjusted through one-time stock grants and bonuses, rather than through adjustment in base pay, *even if there was no sharing at all*. In such an example, the sharing effect that Dr. Leamer claims he has estimated instead would result from the firm's decision to use a form of compensation that avoided sharing.[39] In other words, Dr. Leamer's model gets it completely backwards.

49. Of course, compensation, especially bonuses and stock grants, has transitory components for reasons unrelated to internal equity. Firms use bonuses and stock grants to provide incentive-based pay[40] that is based on a measure of performance, such as individual or group performance or an individual's or group's contribution to firm profits or revenues. But human performance is subject to many random factors, and exceptional performance often will not recur (or recur as strongly) in subsequent years.[41] This is reflected in the salesman example I gave above. In that

[37] Leamer Dep. at 634:3-635:6.

[38] Leamer Dep. at 690:5-691:22.

[39] Dr. Leamer's conduct regression estimates undercompensation based on total compensation, which includes one-time stock grants and bonuses. Therefore, even if one were to accept the results of his conduct regression, those results may be caused by the types of compensation that Dr. Leamer admits might not be shared.

[40] Susan E. Jackson et al., Managing Human Resources. Eleventh Edition, Chapter 11.

[41] At his deposition, Dr. Leamer stated that he believed that there would not be "measurement error" or "randomness" in compensation that "create regression to the mean" (Leamer Dep. at 642:12-643:10). However, this is incorrect. When pay is based on performance there will be random elements of pay due to the fact that there are many factors that determine performance beyond the skill level of the individual. Of course, this is not random like flipping a coin; it simply means there are many factors other than the measurable productivity of the individual or group that contribute to performance (and thus pay), and that such factors will vary over time. For example, the

case, we will observe reversion to the mean absent any concerns over internal equity, any rigidity in pay structure, and any conscious action by the firm other than to pay for performance.

50. Thus, Dr. Leamer's conclusion that Defendants' data is generated by a causal "sharing" relationship, and that the coefficient on the lagged sharing variable "measures the extent to which corrective action is taken at the company,"[42] is unjustified. It reflects a misinterpretation of the data, because he fails to take into account the empirical regularity of reversion to the mean.

51. Plaintiffs rely heavily on this lagged sharing term as evidence for their sharing and somewhat rigid compensation structure claims. In particular, they claim in their Motion that I cannot explain Dr. Leamer's finding that "gains for some are shared with others *in a subsequent year*."[43] But their claim is false – there is a very simple explanation for this finding, one that is well-established in the labor and econometrics literature[44] but overlooked by Dr. Leamer – namely, that reversion to the mean is expected in job-level compensation data. This is not because firms are "sharing" increases or trying to equalize compensation changes across firm. Plaintiffs simply rely on the mistaken belief that one can infer a causal relationship from the fact that high values of a time series are followed by lower values, and low values are followed by higher values.

52. Thus, Dr. Leamer confuses predictable reversion to the mean in the data with evidence of a somewhat rigid compensation structure. The data on compensation growth by title says something very different. There is substantial long-run volatility in compensation across jobs, and this volatility results in reversion to the mean.

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batting averages of individual players and even teams exhibit strong reversion to the mean because the relationship between skill and outcomes is highly imperfect (*see*, for example, Nate Silver, *The Signal and The Noise* (2012)).

[42] Leamer Supplemental Report ¶26.

[43] In Re: High-Tech Employee Antitrust Litigation, *Plaintiffs' Supplemental Motion and Brief in Support of Class Certification*, August 8, 2013 ("Motion") at 24.

[44] Chang Hwan Kim and Christopher R. Tamborini, "Do Survey Data Estimate Earnings Inequality Correctly? Measurement Errors Among Black and White Male Coworkers," Social Forces (2012). Donggyun Shin and Gary Solon, "New Evidence on Real Wage Cyclicality within Employer-Employee Matches," Scottish Journal of Political Economy 54 (2007).

D. Empirical Evidence Shows that Dr. Leamer's Regression Results do not Reflect the Causality Required by his Theory to Support Plaintiffs' Claims of Class-Wide Impact

53. Dr. Leamer claims that his regression identified impacts of "sharing" and "catch-up" (or "corrective action") from forces of internal equity and a "somewhat rigid" compensation structure at each Defendant. He also claims that the relative unimportance of external market forces (measured by information sector employment in the San Jose MSA) demonstrates that the change in compensation for a job title within a firm is not driven by outside influences, such as changes in market compensation. I now use other data where "sharing" forces are not present to demonstrate that the (misnamed) "sharing" effect is an artifact of Dr. Leamer's regression specification.

1. The Same False "Causality" is Found with Another Compensation Dataset

54. The fallacy of Dr. Leamer's inference is demonstrated by applying his regression model to wage and employment data for the overall U.S. economy. In these data, compensation cannot be driven by the force of internal equity combined with a rigid compensation structure within a firm. I use data on individuals from the American Community Surveys ("ACS")[45] for the period 2001 to 2010 to calculate average annual compensation for hundreds of occupations in the U.S. economy – jobs such as computer software (applications) engineers; farmers and ranchers; and paralegals and legal assistants. I replicate Dr. Leamer's regression by substituting occupation-level compensation for job-title compensation; U.S. average annual compensation for average class-wide compensation;[46] U.S. real GDP per worker for average firm revenue per employee; and U.S. total employment for San Jose information sector employment. Thus, my regression replicates both the factors that Dr. Leamer claims determine average job-title compensation (his

[45] The ACS database is obtained from IPUMS-USA (Integrated Public Use Microdata Series) which is a project "dedicated to collecting and distributing United States census data." (https://usa.ipums.org/usa/) "The Integrated Public Use Microdata Series (IPUMS-USA) consists of more than fifty high-precision samples of the American population drawn from fifteen federal censuses and from the American Community Surveys of 2000-2011." (https://usa.ipums.org/usa-action/faq) "The ACS is a project of the U.S. Census Bureau that has replaced the decennial census as the key source of information about American population and housing characteristics. ... The 2000 ACS is an approximately 1-in-750 public use sample consisting of 372,000 person records. Public use samples from the 2001-onward ACS are even larger. The 2001-2004 samples each represent approximately 0.4% of the population, including more than 1,000,000 person records per sample. The 2005-onward ACS datasets are full 1% samples containing more than 2,800,000 person records." (https://usa.ipums.org/usa/acs.shtml).

[46] Like Dr. Leamer, I exclude the given occupation from the calculation of U.S. average compensation.

"sharing" and "catch-up" variables) and the factors that he claims do not affect, or have a much weaker influence on, average job-title compensation (firm revenue and external factors).

55. Exhibit 10 compares Dr. Leamer's results with those I obtain using the ACS data. As the exhibit shows, coefficient estimates on variables that are analogous to variables in Dr. Leamer's specification are similar to those he finds in his regression. If anything, they show a stronger impact in the supposed "causal" directions of "sharing" and "catch-up" than he finds. For the data as a whole, the weighted average coefficient estimate on the "contemporaneous effect" variable is 1.09, compared to only 0.72 in Dr. Leamer's regression. The "lagged effect" or "catch-up" variable has a coefficient estimate of 1.32, compared to only 0.41 in his regression.

56. In addition, as an analogue of Dr. Leamer's "decile-based" regressions using Defendants' data, I performed an analysis where I rank U.S. occupations by their overall average real earnings during the 2001-2010 period in the ACS data, and group them into deciles of roughly the same size (in terms of their fraction in total U.S. employment in the data over this period). Exhibit 11 compares the coefficient estimates from regressions using the ACS data and those from Dr. Leamer's regressions. I find that, in almost all cases across the deciles, the estimated "sharing" and "catch-up" effects are stronger using the ACS data than the ones Dr. Leamer finds using Defendants' data. Thus, interpreted through Dr. Leamer's view of how the marketplace operates, this means that there is greater sharing and catch-up between extremely diverse occupations and unrelated industries and employers than there is for "technical" jobs within an employer.

57. These results, which use national data for widely disparate jobs across all kinds of industries and firms, strongly suggest that Dr. Leamer's results are not capturing what he claims – in short, that his results likely are spurious. The logical interpretation is that they suffer from the reflection problem and reversion to the mean that we expect to be there. While the findings from running his regression on national occupation-level compensation are senseless viewed through Dr. Leamer's economic theory, they are not surprising when that theory is discarded.

58. A variety of common factors would cause average compensation in one occupation to be correlated with average compensation for the U.S. economy as a whole, but Dr. Leamer's hypothesized "internal equity" and "rigid compensation structures" are not among those factors. Common influences, such as the overall performance of the economy, will cause average

compensation for most occupations to move in a common way with the aggregate economy. But this no more demonstrates that compensation for farmers is "catching" up to preserve "fairness" relative to paralegals than it can be concluded that Dr. Leamer's regressions demonstrate "fairness" and causation within the Defendants' data.

2. A Regression Model that Explains the Change in Chicago Temperature as "Catch-up" from the Difference between Chicago and Milwaukee Temperatures Illustrates Dr. Leamer's Misleading Conclusions

59. The misleading conclusions caused by ignoring the "reflection problem" and "reversion to the mean" are not limited to regressions using labor market compensation data. To illustrate how easy it is to get results like those presented by Dr. Leamer, and how wrong the conclusions that can be drawn when an analyst ignores basic statistics, I use data on daily temperature for two cities: Chicago (where I live) and Milwaukee (a nearby city). In keeping with Dr. Leamer's specification, I examine changes in daily temperature in one of the two cities (e.g. Chicago), using as explanatory variables (a) changes in the temperature of the "reference" city (e.g. Milwaukee), and (b) prior day's temperature difference between the reference city and the city under study. The first explanatory variable is analogous to Dr. Leamer's contemporaneous "sharing" variable, and the second variable is analogous to his "catch-up effect" variable.

60. Exhibit 12 shows the results of this analysis. The left panel presents results for Chicago and the right panel presents results for Milwaukee. "Model 1" shows estimates from a simple specification including just the "sharing" and "catch-up" variables. Not surprisingly, the results mirror those presented by Dr. Leamer. The coefficient estimates on both variables are positive. Given how Dr. Leamer interprets similar results from his regression, he would conclude that, for example, the positive coefficient on the second variable implies that there is "corrective" action to lower Chicago's temperature and increase the temperature in Milwaukee when yesterday's temperature in Chicago is warmer than normal.

61. The effect of adding common factor variables, and thus running the Dr. Leamer-type horse race, is illustrated in the next two columns. "Model 2" includes only indicator variables for months of the year as explanatory variables, and does not contain the "sharing" or "catch-up" variables. The results agree with intuition: as can be seen from coefficient estimates on the

month indicator variables, temperature begins to fall in August, declines rapidly through the fall, and then begins to rise in February.

62. In the next "Model 3" column, I combine the explanatory variables from Model 1 and 2. Now the sensible monthly pattern is gone. Instead, coefficient estimates on the month variables would seem to suggest that for Chicago, temperature increases in every month of the year and for Milwaukee, temperature decreases in every month of the year. This happens because coefficients on the month variables no longer reflect their actual effects on temperature. Instead, measurement of the monthly pattern is confounded by what Dr. Leamer would call contemporaneous "sharing" and lagged "catch-up" variables. Dr. Leamer would thus come to two conclusions – both of which contrary to common sense – that changes in Chicago temperature can be explained by "sharing" or "catch-up" effects with Milwaukee temperature.

E. Conclusion

63. Dr. Leamer's correlation and regression results reflect the same pattern of "sharing effects" that one would find in national level labor market data, a regression analysis to explain changes in the daily temperature in Chicago based on the lag of temperature in Milwaukee, or using other data on related time series that have both common and idiosyncratic effects. Dr. Leamer confuses well-known and predictable properties of regressions of related time series with causal effects. He characterizes his results as evidence of "sharing" generated by concerns about internal equity and compensation policies that enforce a somewhat rigid wage structure, but his inference is at odds with sound econometric practice.

64. In their Motion for Reconsideration, Plaintiffs dispute the explanation I provided in my previous report[47] for why the data are consistent with Defendants' employees' compensation being determined by competition in a broad labor market, with highly individualized adjustments for unique circumstances of individual employees, such as information received through a cold call.[48] They claim instead that Dr. Leamer's regression analysis in his Supplemental Report demonstrates that my "speculation" is "unsupportable." Yet, the evidence that I provided above,

[47] In Re: High-Tech Employee Antitrust Litigation, Expert Report of Professor Kevin M. Murphy, November 12, 2012.

[48] Motion at 24.

like that in my previous report, shows that, far from disproving my conclusion, Dr. Leamer's empirical findings are consistent with the existence of a broad labor market in which employee compensation is affected by individual factors, such as information revealed during a cold call, but the impact of such events on other employees is limited and does not spread to the entire proposed class. Dr. Leamer's results are fully consistent, and indeed expected, if a reduction in cold-calling would not have class-wide impact.

V. DR. LEAMER DOES NOT ESTABLISH THAT THE PROPOSED TECHNICAL CLASS IS PROPERLY DEFINED

65. Dr. Leamer claims that he "do[es] not find persuasive evidence to suggest that there are sizeable groups whose compensation might have been disconnected from Defendants' somewhat rigid compensation structure"[49] or that there is any way to "identify and exclude from the Technical Class job titles based on a lack of these positive correlative relationships."[50] In other words, Dr. Leamer appears to argue that Plaintiffs' have defined the class "just right," or at a minimum in a way that would permit the boundary of that proposed class to be evaluated empirically, no basis for including all jobs that could qualify as "technical" in their proposed class, no matter where located in the country.

66. Dr. Leamer's opinions about the composition of the proposed class have no merit given that, as I demonstrated above, his empirical evidence has not established any causal relationship between cold-calls that affect one job title and compensation provided to employees with other job titles, let alone a class-wide impact. While it is possible that there would be some forces within a company that would cause adjustment of compensation of some other employees in response to a cold-call, Dr. Leamer has no basis on which to identify the scope of such influence or to conclude that large portions of the proposed class are not unaffected by the challenged agreements. What matters in determining "common impact" for a class as large and diverse as the proposed Technical Class is not the average extent of linkage between different groups (such as job titles), but that the linkages spread across all (or nearly all) the groups included in the proposed class. Even if correlation mattered for understanding whether some kind of "causal"

[49] Leamer Supplemental Report ¶10.

[50] Leamer Supplemental Report ¶11.

relationship existed between certain groups, the average level of correlation would not be informative about whether all those groups belong in the same class. Rather, the correlation would have to be high for all, or nearly all groups in the proposed class (again, if as Dr. Leamer claims, correlation itself were informative, which it is not).

VI. DR. LEAMER'S CONDUCT REGRESSION REMAINS UNINFORMATIVE

67. Dr. Leamer's Conduct Regression suffers from errors that render it uninformative.

68. First, the Court noted that "Dr. Leamer's report is slightly ambiguous as to whether any variables besides revenue should have been included to control for correlations across employees…To the extent there are other variables that may improve the accuracy of the Conduct Regression and obviate the need for clustering, Dr. Leamer is encouraged to include them in his next report."[51] Dr. Leamer did not take the opportunity to do so. His argument that these common factors all can be taken into account simply by including additional measured common factors is simply wrong, even if it were feasible to do so given that these factors will differ across Defendants (thereby requiring inclusion of Defendant-specific variables). In any event, Dr. Leamer's failure to respond to the Court's suggestion leaves unknown what method he thinks could be used to demonstrate that his Conduct Regression has any probative value.

69. Second, Dr. Leamer acknowledged at his deposition that he responded only to one of the models that I offered in my original report to demonstrate that he wrongly assumed a common conduct effect for all Defendants,[52] and he claimed that the model that he had critiqued had "overwhelmed the data."[53] However, he did not comment on the more parsimonious model that I also offered, which included fewer explanatory variables but which still permitted measurement of separate Defendant-specific conduct effects.[54] My second model (Appendix 11 of my Original Report) includes Defendant-specific conduct measures by interacting the conduct

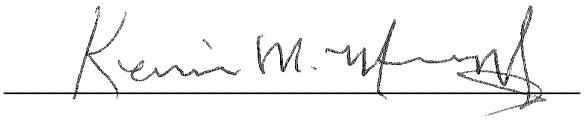
[51] Order fn. 15.

[52] Leamer Dep. at 770:25-771:13.

[53] Leamer Dep. at 770:19-23.

[54] When asked if he recalled "any reason why you didn't offer a criticism of that second approach by Dr. Murphy in your … reply declaration," Dr. Leamer responded "Presumably because I didn't have comments to make about it" (Leamer Dep. at 771:6-13).

variable with each defendant. I reduced the number of explanatory variables by not including interactions between conduct and age, and conduct and hiring rate, because as I explained the interactions with age and hiring rate added very little power to the regression. My results (on which Dr. Leamer did not comment on) showed large variation in the size and even the *sign* of the estimated undercompensation effects, with the estimates indicating that employees at Adobe, Lucasfilm and Pixar were not undercompensated, but instead were overcompensated. This indicates that Dr. Leamer had no basis to assume a common impact across Defendants. Dr. Leamer's Table 1 and 2 in his Supplemental Report, which show that there are low or even negative correlations in average total compensation between certain Defendants, also show that one cannot simply assume common impact across Defendants.



Kevin M. Murphy

June 21, 2013

TECHNICAL APPENDIX: MODELLING THE REFLECTION PROBLEM

1. In order to mathematically model the reflection problem in the context of Dr. Leamer's analysis, and thereby illustrate why his conclusions are unjustified, I consider a hypothetical firm with J jobs, each of which has an equal number of employees. Compensation in each job is determined by two types of factors: (1) common factors (firm-level success, changes in the general economy, etc.) and (2) job-specific factors (group-level performance, changes in the market for individual skills, etc.). I assume that compensation for each job is determined by the sum of these two factors. I denote the common factors by A, and the job specific factors by e. Thus, compensation of job j in year t, w_{jt} is given by

(1) $$w_{jt} = A_t + e_{jt},$$

where A_t reflects the influence of the common factors in year t and e_{jt} reflects job-specific factors for job j in that year.

2. I assume that the job-specific factors are independent of (uncorrelated with) one another, and thus there is no "sharing." Transforming equation (1) into year-over-year changes yields for job *j*

(2) $$w_{jt} - w_{jt-1} = (A_t - A_{t-1}) + (e_{jt} - e_{jt-1}).$$

The change in average compensation for jobs other than job j is given by

(3) $$w_{-jt} - w_{-jt-1} = (A_t - A_{t-1}) + \frac{1}{J-1}\sum_{i \neq j}(e_{it} - e_{it-1}).$$

3. Equations (2) and (3) describe the true process that determines compensation changes in this model, namely the contributions of changes in common and job-specific factors.

4. Now consider a regression analysis analogous to that performed by Dr. Leamer, in which the researcher wants to use these data to understand whether there is "sharing" of the type he claims. The type of regression model specified by Dr. Leamer is:

(4) $$w_{jt} - w_{jt-1} = \alpha + \beta(w_{-jt} - w_{-jt-1}) + \varepsilon_{jt},$$

with the change in compensation for one job modeled to be "explained by" the change in compensation of all other jobs, rather than by the changes in common and job-specific factors

that generate the data. It then is straight forward to show that the regression coefficient on the change in the average compensation, β, in equation (4) will be given by

$$(5)\quad \hat{\beta} = \frac{\sigma_A^2}{\sigma_A^2 + \frac{1}{J-1}\sigma_e^2}$$

where σ_A^2 is the variance of the changes in the common factors and σ_e^2 is the variance of the changes in the job-specific factors.

5. Equation (5) has the important implication that, when the average outcome variable (in this case average compensation growth) is obtained by averaging over a large number of jobs, the resulting average largely will reflect common factors because the idiosyncratic job-level factors will tend to average out. The denominator in equation (5) is the variance of the change in class-wide average compensation, while the variance of changes in job-level compensation is

$$(6)\quad \sigma_A^2 + \sigma_e^2 \ .$$

Equation (5) shows that the importance of common factors is amplified in the class-wide variables because the contribution of job-specific factors is reduced by the factor 1/ (J-1) <1. For example, if there are 25 jobs, then the contribution of job-specific factors is reduced by a factor of 24 (= 25-1). This means that the change in average compensation variable effectively serves a proxy for the common factors that affect firm-wide compensation. These common factors will be picked up by (and attributed to by an analyst using Dr. Leamer's approach) the average compensation change variable, even if they are a small part of what drives job-level compensation.

6. This proxy effect can be illustrated by considering a simple example where common factors account for only 20 percent of job-level variation and there are 25 equally sized jobs in the firm. The fraction of variance in job-level compensation changes accounted for by the common factors is equal to $\sigma_A^2/(\sigma_A^2+\sigma_e^2)$, which implies that σ_e^2/σ_A^2=4. Under these conditions, equation (5) implies that we would expect a regression coefficient of 1/(1+4/24) =0.86 on the average wage change variable and a correlation between job-level and average compensation. Thus, even though *by construction*, common factors account for only 20 percent of overall changes in compensation and there is no sharing at all (i.e., changes in compensation for an individual job have no effect on compensation in other jobs by construction), an analyst using Dr. Leamer's methodology would conclude that the compensation structure displays

"astounding" correlation, is "somewhat rigid" and most importantly (and most egregiously for purposes of evaluating Plaintiffs' claims) that 86 percent of the change in average compensation is "shared." This would be true in spite of the fact that there is zero actual sharing and thus no reason why an entire putative "class" of all employees at the firm possibly could be harmed by actions that affect some individuals or even some jobs.

7. Dr. Leamer claims that he was able to reject an alternative theory that his results reflected the influence of common factors by running a horse raise with his "sharing" theory. However, my model shows why he is wrong. Assume that there are some measured common factors, and that these variables capture a fraction R^2 of the variance of the common factors. Then, the coefficient on the average compensation change variable becomes

$$\hat{\beta} = \frac{(1-R^2)\sigma_A^2}{(1-R^2)\sigma_A^2 + \frac{1}{J-1}\sigma_e^2} \quad (7)$$

8. If one adds variables to the regression that explain one-half of the common factor effect (i.e. R^2=0.50), this implies a regression coefficient of 0.75 (versus 0.86 in the regression without the control variable). Importantly, the estimated coefficient on the common factors in the regression would be only one-fourth of its true size, causing the researcher to greatly understate its influence. Adding factors that explain less than 50 percent of the common components generates even smaller changes. For example, adding factors that explain 20 percent of the common factors would result in a "sharing" coefficient of 0.83 (versus 0.86 without controls) and a coefficient on the common variable equal to only about one sixth of its actual size.

Derivation of Equation (7) and Estimated Coefficient on Common Factors

For simplicity of notation, I now denote everything in changes. Consider also that everything on the right hand side is independent of each other

$$w_{jt} = A_t + e_{jt}$$

$$w_{-jt} = \frac{1}{J-1}\sum_{i \neq j} w_{it} = A_t + \frac{1}{J-1}\sum_{i \neq j} e_{it}$$

Now assume that

$$A_t = X_t + u_t$$

X is observed variable orthogonal to u.

Regress w_{jt} and w_{-jt} on X to get residuals. These are

$$\tilde{w}_{jt} = u_t + e_{jt}$$

$$\tilde{w}_{-jt} = u_t + \frac{1}{J-1}\sum_{i \neq j} e_{it}$$

Now run OLS to get β.

$$\beta = \frac{\sigma_u^2}{\sigma_u^2 + \frac{1}{J-1}\sigma_e^2}$$

By definition

$$\sigma_u^2 = \sigma_A^2(1-R^2)$$

This yields

$$\beta = \frac{\sigma_A^2(1-R^2)}{\sigma_A^2(1-R^2) + \frac{1}{J-1}\sigma_e^2}$$

To get the coefficient on X we regress

$$w_{jt} - \beta w_{-jt} = (1-\beta)(X_t + u_t) + e_{jt} - \frac{\beta}{J-1}\sum_{i \neq j} e_{it}$$

on X.

This gives a coefficient of (1-β) versus the true coefficient of 1.